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ABSTRACT

In 1993 a new mathematics education program was implemented at Utah State University (Logan) in a cooperative effort of the university's Department of Elementary Education and Department of Mathematics and Statistics. The program is designed to increase teacher awareness and classroom utilization of teaching strategies that develop pupil understanding and appreciation of relationships between mathematical concepts and real-life experience or phenomena. As part of the evaluation program, a longitudinal study is being conducted to identify the degree to which course goals and objectives are successful. The first phase describes the development, implementation, and evaluation of the preservice mathematics teaching strategies course and uses a mixed-method analysis strategy to generate criteria and variables used to assess relevant instructional practice. The second phase, to be undertaken in 1995, will describe and evaluate the degree to which course participants implement relevant instructional practices in their respective classes. Results from the first phase indicate that the mixed-method, data consolidation/merging analysis strategy (V. J. Caracelli and J. C. Green, 1993) is an appropriate model for studying relevant instructional practice. Four criteria were identified that may define relevant instructional practice, and two variables were identified as important considerations for phase 2 data collection and analysis. Three tables present study findings. (Contains 21 references.) (Author/SLD)

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An Evaluation of a Model Elementary Mathematics Education Program Designed to Increase Relevant Instructional Practice

Phase One: Program Description and Identification of Variables

by

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Abstract

Beginning in September, 1993, a new mathematics education program was implemented at Utah State University. Undertaken in a cooperative effort by faculty from the Department of Elementary Education and the Department of Mathematics and Statistics, this program is designed to increase teacher awareness and classroom utilization of teaching strategies which develop pupil understanding and appreciation of the relationships between mathematical concepts and real-life experience or phenomenon.

As part of program evaluation, a longitudinal study is being conducted to identify the degree to which course goals and objectives are successful in increasing teacher awareness and utilization of relevant instructional practice. The study is comprised of two phases. The first phase describes development, implementation, and evaluation of the pre-service mathematics teaching strategies course and employs a mixed-method analysis strategy to generate criteria and variables used to assess relevant instructional practice. The second phase, to be undertaken in 1995, will describe and evaluate the degree to which course participants implement relevant instructional practices in their respective classes.

Results from the evaluation's first phase indicate that the mixed-method, data consolidation/merging analysis strategy (Caracelli and Greene, 1993) is an appropriate model for providing additional insights and perspectives on relevant instructional practice. Four criteria were identified which may define relevant instructional practice, and two variables were identified as important considerations to phase two data collection and analysis.

Purpose

The purpose of this phase of the evaluation is to identify and describe program characteristics, to identify criteria used to define relevant instructional practice in elementary level mathematics education, and to generate variables to be used in assessment of the degree to which graduates of the program employ relevant instructional practices in their classrooms.

This paper will describe development and implementation of the pre-service elementary mathematics methods course and evaluation measures used in the mixed-method information gathering phase, and provide information on perceptual and attitudinal outcomes. In addition, this report includes a list of recommended revisions to course curriculum.

Relevant Instructional Practice

Relevant instructional practice is a phrase used by the authors in reference to pedagogy wherein a learner expresses an interest in pursuing study of a particular topic or concept, recognizes the practical significance of that topic, and extends subsequent conceptual understanding by reflecting upon additional applications or generating new theoretical considerations. The underlying premise for this instructional approach is that active, real-world experience and knowledge precedes conceptual understanding (Dewey, 1902; Piaget, 1966; Vygotsky, 1962).

Relevant instructional practice in mathematics education is similar to other contextual teaching approaches in that the relationship between a specific mathematical concept and knowledge of why that concept is important and how it is used in the everyday experience of the perceiver is explicit. The practice is distinguished from other contextually oriented teaching approaches such as, "Mixing" (Carss, 1986), "Didactical Solution" (Freudenthal, 1983), or "Modeling" (Heller, Ahlgren, Post, Behr, & Lesh, 1989) in two distinct

ways. First, the real-world experiences that eventually lead to development of specific concepts are initiated from teacher or student interests. For example, a playhouse building activity was recently initiated by a teacher with an expertise and interest in building. The activity served to introduce and reinforce measurement and geometry concepts (Dorward, & Archibald, in press).

Second, relevant instructional practice necessitates extending understanding of the conceptual and utilitarian relationship to include additional application, idea generation, and speculation by reflecting upon what has been learned or experienced. Using the previous example, concepts learned during the playhouse building project may, upon reflection, develop insights on new building materials or techniques or lead to greater understanding of the historical evolution of shelters. This second component models the type of sophisticated thinking characteristic of creative problem solvers, artists, and theoreticians who seek patterns that help connect knowledge with meaning (Caine, & Caine, 1991; Duckworth, 1987).

Justification for the Study

In recent years, there have been repeated calls for reform in teacher education (American Association for Higher Education, 1990; Holmes, 1990; National Council of Teachers of Mathematics, 1989). A recurring theme in these calls is the need to develop greater understanding of the interrelationships between conceptual understanding and real-life experience. State and national educational organizations have recognized the importance of connecting academic with real-world experience, particularly in the study of mathematics (NCTM, 1989; Utah State Office of Education, 1992).

Much of the concern over a perceived lack of relevance in traditional mathematics instruction has evolved as a result of a growing body of research

in support of the cognitive psychological theory of knowledge acquisition (Noddings, 1990; Schoenfeld, 1987). An underlying assumption of cognitive psychology is that people construct knowledge through interaction with a variety of experiences. When academic experiences are devoid of links to practical or theoretical applications, vital connections and associations to previous knowledge and understanding are lost (Wilensky, 1992). In recent reports, several prominent educational organizations recommend increased emphasis on establishing connections between concepts and their applications, primarily through integrated study and investigation (Mathematical Association of America, 1989: National Council of Teachers of Mathematics, 1989, 1991; National Research Council, 1991).

Integration of conceptual knowledge with practical applications in ways that take advantage of previous student experience and understanding pose a challenge for public school and teacher education programs. Public school teachers are often constrained by current curricular and evaluation demands, by access to appropriate teaching resources, and by an understanding of how children learn (Duckworth, 1987). As evidenced by a recent teacher survey, NCTM has identified "a large gap between the widely praised national teaching and student achievement standards ... and what actually happens in math classes" (RR, 1992, p. 3).

This evaluation is intended, in part, to assess the degree to which the program is successful in aligning what is known about knowledge acquisition with classroom practices. The first phase of the evaluation was designed to describe program characteristics, and identify critical elements of relevant instructional practice and population variables.

Justification for Research Design

There is an adequate body of research to suggest that contextual instructional practices increase student problem solving abilities, spatial abilities, and interest (Mukhopadhyay, 1990; Pinxten, 1987; Smith, & Dunnington, 1986). Little research has been found, however, on elements which characterize contextual teaching approaches or on issues related to preparing teachers to implement relevant instructional practices.

Mixed method research designs have been shown to be most effective in gathering information useful in more formal program evaluations (Caracelli, & Greene, 1993). Talmage and Rasher's (1981) spiral strategy of merging information from qualitative and quantitative methodologies in order to examine increasingly more complex issues served as the model for this phase of the evaluation.

Description of the Sample

Utah State University is one of two major universities in the Utah System of Higher Education and is the state's land-grant university under state and federal legislation. The Department of Elementary Education is the largest department in the University; annually offering courses to approximately 1000 preservice and inservice teachers.

The mathematics education program consists of undergraduate and graduate courses taught by faculty from the Department of Elementary Education and Department of Mathematics and Statistics. The undergraduate participants in this study had taken a minimum of nine quarter hours in elementary mathematics and college algebra as a prerequisite to the mathematics methods course. These participants were all students enrolled in the mathematics methods course, taught by faculty from the Department of Elementary Education during Fall Quarter 1992, and Winter Quarter 1993.

Methods

Initial information gathering consisted of administering a questionnaire and a writing assignment within the first two days of the mathematics methods class. The purpose of the questionnaire was to identify participants' interests, likes and dislikes with regard to mathematics instruction, experiences with technology, and degree of exposure to the state and national mathematics standards. The initial writing assignment asked the preservice teachers to define mathematics and identify how mathematics should be taught based upon how they thought children learned best.

During the course, the authors collected anecdotal information on student attitudes, involvement in class activities, and demonstrations of articulable expansion of concepts or ideas expressed by the instructors. This information provided evidence used in identification of variables for between group analysis.

Information was also gathered from the final exam for the mathematics methods class. Students were asked to identify how their initial opinions of mathematics teaching strategies had been changed or reinforced as a result of participating in the class. Lastly, eight students were randomly selected from four categories to participate in an interview designed to identify specific aspects of the course which influenced development of beliefs about how mathematics should be taught.

Prior to information analysis, the authors reviewed pertinent literature to identify possible elements used to define or characterize contextual teaching practices. These elements served as a template for assessing the degree to which students identified characteristics of relevant instructional practice as important considerations in teaching before and after taking the mathematics methods course.

Responses from participants were grouped according to gender and student type. Participants whose ages were less than one standard deviation above the mean age were considered traditional students. Those participants whose ages were more than one standard deviation above the mean were considered non-traditional students.

Initial examination of data by both investigators assessed the degree to which respondents identified elements of relevant instructional practice as important considerations in teaching mathematics, change in articulation of those elements from the beginning to the end of the course, and compatibility of statistical determination of student type with subjective anecdotal information.

Results

Students enrolled in the mathematics methods class for preservice teachers attended class for a total of twenty-two and one-half hours of instruction. The mathematics class was one of four elementary education methods classes which students take concurrently. Students attended either a morning or afternoon session and participated in a practicum experience in a local elementary school for the remaining half-day.

The mathematics methods course was designed to prepare students to teach mathematics in elementary and middle school classrooms. The major goal of the course was to connect students' teaching strengths and understanding of how children learn, with their knowledge of mathematics and theoretical approaches to instruction. Through the integration of theory and practice, the preservice teachers explored instructional topics including problem solving, numeration, the four basic operations, geometry, measurement, rational numbers, algebra, and technology. Course instructors utilized a wide variety of instructional practices, evaluation procedures, and

teaching materials so students could experience and reflect upon diverse methods and resources.

Relevant instructional practice was a major theme throughout the undergraduate methods course. The instructors encouraged students to connect mathematical content to real life, to other content areas, and to specific mathematical content (i.e. showing the relationship between fractions, decimals, and percentages). In making these connections, the future teachers demonstrated conceptual relevance in their practicum experiences.

Course instructors also emphasized the integration of mathematics with other subject areas. The instructors provided many examples of how children's literature could reinforce specific mathematical concepts, appeal to children's visual or fantasy interests, or increase pupils' motivation to learn. The preservice teachers also developed instructional activities based upon student and teacher hobbies or interests.

Demographics

The authors identified two variables for correlation analysis with the critical elements. These variables were gender and student type. Participants whose ages were more than one standard deviation above the mean, or who were at least age 30, were categorized as non-traditional students.

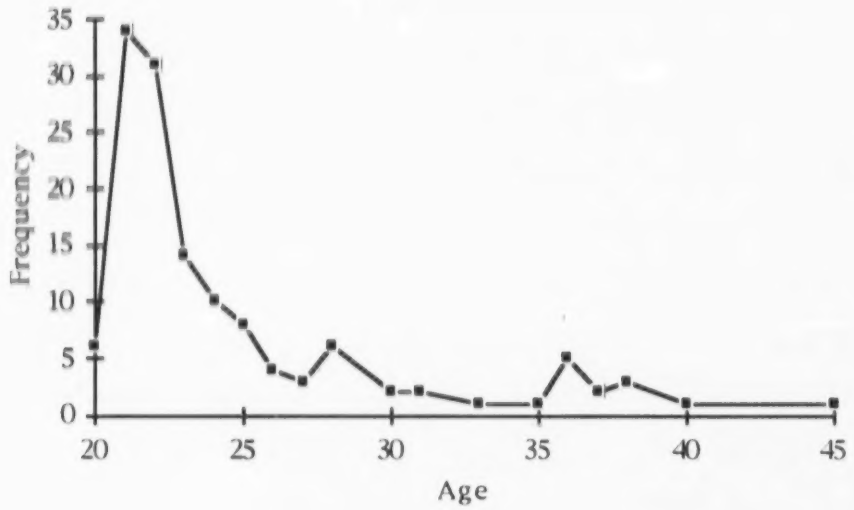
Of the 134 preservice teachers in the sample, ten (7.46%) were traditional male students, 116 (86.57%) were traditional female students, two (1.49%) were nontraditional male students and six (4.48%) were nontraditional female students (See Table 1).

Figure 1: Student Type and Gender Distribution

Student Type	Gender	Frequency	Percent
Traditional	Male	10	7.46%
	Female	116	86.57%
Nontraditional	Male	2	1.49%
	Female	6	4.48%

The participants ranged in age from 20 to 45 (See Figure 1). The mean age of students in the mathematics methods course was 28.

Figure 1: Age Distribution (n=134)



Based on the assignments completed by participants, student attitudes throughout the course, and contributions made by the participants during class, the researchers questioned the appropriateness of using participants' ages as the sole determiner of traditional or nontraditional status. Some students who were younger than one standard unit above the mean age

exhibited additional characteristics associated with nontraditional students. For example, several younger students who had professional work experience or had raised a family displayed a maturity of thought similar to that which was characteristic of the older students. The question of categorizing according to age is one that the authors will examine more closely as a result of this evaluation.

Critical Elements

Prior to analyzing the information, the researchers identified eight critical elements which define or characterize contextual teaching approaches. These eight elements were: 1) use of hands-on manipulatives, 2) the integration of technology, 3) compliance with current national and state standards for revising mathematics curriculum and instruction, 4) modeling positive attitudes toward mathematics, 5) curriculum motivated by teacher or student interests, 6) connection of mathematics to literature, 7) expression of need to link instruction with practical application, and 8) cross-disciplinary integration. These elements, identified from literature on contextual strategies, served as the template for initial examination of information.

Analysis of the information revealed that several of the original elements were consistently represented by respondents in ways that were not characteristic or supportive of linking mathematics concepts to their practical applications. For example, participants commonly cited the use of hands-on manipulatives and cooperative learning strategies to illustrate how mathematics should be taught. At the same time, those elements were never mentioned within the context of use in modeling real-life experiences.

The investigators noted that students always identified four of the original eight elements (conceptual relevance, subject integration, literature connections, and interest motivated curriculum) within the context of

meaningful instruction. Interestingly, this observation held for both traditional and nontraditional students across pre-course and post-course evaluation measures.

The investigators also assessed the frequency with which students identified elements of relevant instructional practice before and after taking the mathematics methods class. The element of conceptual relevance was most frequently identified as an important consideration in mathematics instruction in both pre-course and post-course measures. A substantial increase appeared between traditional students' pre-course and post-course evaluation measures on the value of integrating mathematics with other discipline areas. There was also a noticeable increase in the frequency with which female students and traditional male students emphasized the connection of literature to mathematics. The only increase in identification of interest-motivated mathematics appeared in the responses from traditional female students (See Tables 2 and 3).

Table 2: Frequencies of Element Use Among Traditional Male and Female Preservice Teachers

Elements	Pre-course Traditional Male	Pre-course Traditional Female	Post-course Traditional Male	Post-course Traditional Female
Literature Connection	0 (0%)	9 (8%)	1 (10%)	16 (14%)
Subject Integration	1 (10%)	31 (27%)	1 (10%)	76 (66%)
Conceptual Relevance	4 (40%)	72 (62%)	8 (80%)	95 (82%)
Interest Motivated	1 (10%)	1 (1%)	0 (0%)	14 (12%)

Table 3: Frequencies of Element Use Among Non-traditional Male and Female Preservice Teachers

Elements	Pre-course Non-traditional Male	Pre-course Non-traditional Female	Post-course Non-traditional Male	Post-course Non-traditional Female
Literature Connection	0 (0%)	1 (17%)	0 (0%)	3 (50%)
Subject Integration	0 (0%)	4 (67%)	0 (0%)	5 (83%)
Conceptual Relevance	2 (100%)	6 (100%)	2 (100%)	6 (100%)
Interest Motivated	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Discussion

This paper reports on the first phase in a longitudinal study evaluating the degree to which Utah State University's mathematics education program increases relevant instructional practice in the elementary classrooms. The purpose of this phase was to describe aspects of the program, identify elements which define relevant instructional practice, variables for future analysis of between group variance, and other questions which may be important considerations in subsequent evaluation.

The apparent lack of information on instructional practice that initiates from teacher or student interests, focuses on relationships between conceptual knowledge and pertinent real-world application, and encourages subsequent reflection on additional connections or hypotheses, necessitated a mixed-method evaluation methodology. The spiral strategy was effective in providing the investigators with additional insights and perspectives. The list of potential elements defining relevant instructional practice drawn from the literature was refined in phase one. The investigators generated additional insight on defining characteristics of traditional and nontraditional preservice teachers through information analysis.

Subsequent evaluation efforts will be afforded an additional level of specificity as a result of this work. These efforts will include: a) preparation of an evaluation instrument that identifies the degree to which preservice teachers believe elements of relevant instructional practice are important in mathematics teaching, b) selection of comparison groups based on identified criteria, and c) continued refinement of course curriculum to increase utilization of appropriate teaching practices.

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